InAsN Grown by Plasma-Assisted Gas Source MBE

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Abstract

The huge bowing effect on the band gap energy makes InAsN alloy a promising material for infrared applications [1]. However, only very limited efforts were put on this materials because previous studies demonstrated problems of phase separation and immiscibility on the growth of InAsN with high nitrogen content [2]. Nonetheless, there are no existing definitive results on the synthesis of this alloy. Recently, we demonstrated InAsN/InGaAsP quantum wells on InP substrates with a 10K PL peak wavelength as long as 2.6μm[3]. In this study, we report the growth of InAsN bulk layers on InP substrates by using a VG gas source MBE with an EPI UNI-bulb RF plasma K-cell. The samples were grown at 460°C. The thickness is 2 μm, and the N composition ranges from 0 to 6%. Fig.1 shows the DXRD spectra of InAs and InAsN samples. It is clear that the diffraction peak of the InAsN samples shift closer to the InP substrate peak, compared with that of InAs sample. A dynamic simulation program, RADS, was used to determine the nitrogen composition of InAsN samples. Although N was added into InAs successfully, it also degrades the DXRD linewidths as compared to the referential InAs. Table I shows the Hall results of the samples at 300K. It was found that the carrier concentration of InAsN sample is higher than that of InAs sample, and the more the N composition, the higher the carrier concentration. The possible origin of the high carrier concentration in InAsN sample is not quite clear at the moment. Fig.2 shows the square of the absorption coefficient α^2 versus photon energy plots for InAs and InAsN samples. Two points are worthy of note from this figure. First, the energy of the absorption edge of InAsN samples is always higher than that of InAs. Second, when N composition is lower than 4.8%, higher N composition results in higher absorption edge. But, the trend reverses for InAsN with larger N composition. The phenomenon seems controversy to the theoretical prediction [1]. To interpret the results, Burstein-Moss effect [4] should be taken into account because of the high carrier concentration in these InAsN samples. Samples with lower N composition have smaller effective mass, their Burstein-Moss effect is more significant. The two high N content samples, however, may have larger effective mass and thus less significant Burstein-Moss effect. Their bowing effect on band gap has overcome Burstein-Moss effect. Therefore, the absorption edge of C1078 (6%) has been lower than that of C1077 (4.8%), though the carrier concentration of the former is five times higher than that of the latter. Results of effective mass measurement and detailed quantitative estimation on the band gap and bowing factor of InAsN bulk layers grown on InP substrate will be presented.

Reference

1. S. Sakai, Y. Ueta, and Y. Terauchi, Jpn. J. Appl. Phys., **32**, 4413, 1993.
2. Y. C. Kao, T. P. E. Broekaert, H. Y. Liu, S. Tang, I. H. Ho, and G. B. Stringfellow, Mater. Res. Soc. Symp. Proc., **423**, 5, 1996
3. J. S. Wang, H. H. Lin, L. W. Sung and G. R. Chen, Proceeding of 12th IPRM, 549, 2000
4. E. Burstein, Phys. Rev., **93**, 632, 1954.

Table 1 Hall results of undoped-$InAs_{1-x}N_x$ measured at 300K

Sample	N composition, x	Carrier conc.(cm^{-3})	Mobility(cm^2/Vsec)
C937	0%	2.64E+16	7.66E+3
C1075	0.1%	8.25E+17	3.27E+3
C1076	1.6%	1.91E+18	1.74E+3
C1077	4.8%	3.24E+18	1.28E+3
C1078	6%	1.69E+19	3.81E+1

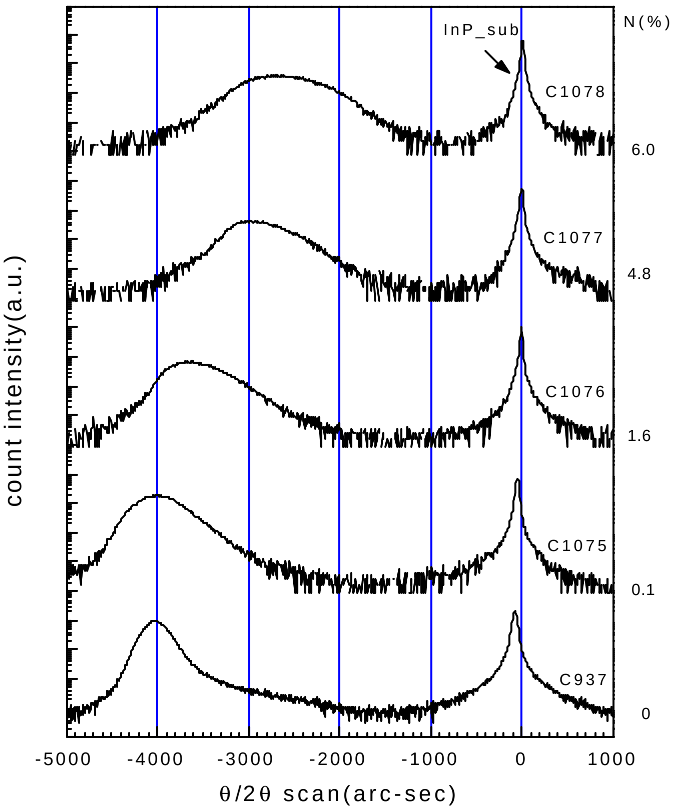

Fig.1 (400) DXRD spectra of a series of $InAs_{1-x}N_x$ bulk samples with x from 0 to 0.06. A dynamic simulation program, RADS, was used to determine the nitrogen composition of InAsN samples.

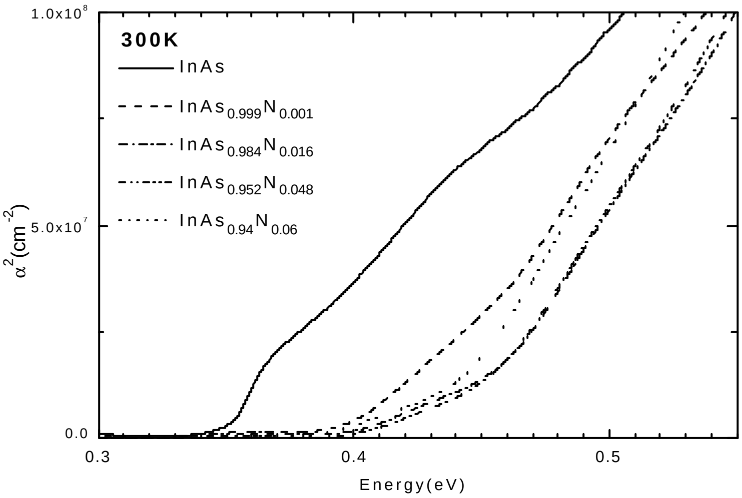

Fig.2 Plots of the square of the absorption coefficient (α^2) against the photon energy deduced from 300K IR transmission spectra recorded on a series of $InAs_{1-x}N_x$ bulk samples with x from 0 to 0.06.